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TEXAS AGRICULTURAL EXPERIMENT STATION

A. B. CONNER, DIRECTOR
College Station, Brazos County, Texas

BULLETIN NO. 409 MARCH, 1930

DIVISION OF RANGE ANIMAL HUSBANDRY

NORMAL GROWTH OF RANGE CATTLE

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS
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**In cooperation with U. S. Department of Agriculture.
***In cooperation with the School of Agriculture.

†As of February 1, 1930.

Growth involves increases in weight and also changes in body shape. Range cattle are largely limited to the natural vegetation for the feed supply which is to support their growth. The result is different kinds and rates of growth at different seasons of the year. This has an important bearing upon problems of when to market, when and how much supplemental feeding should be practiced and other matters of livestock management.

As a first step in studying some of these special problems, the Texas Station presents in this Bulletin a study of the growth in weight and in measurements which actually took place in the calves born during nine years at Substation No. 14, the Ranch Experiment Station. This study so far has been incidental to a breeding problem which prevented the division of the cattle into groups which could be given different amounts of supplemental feed.

Increase in weight is usually very rapid from the middle of April until late summer, slowing down a little in the early fall and coming almost to a standstill in early winter. During late winter and early spring there is an actual loss in weight.

Skeletal growth is more regular than growth in weight. Growth of the head and of the length of the leg bones seems not to be checked at all by the winter period of scanty feed, but growth of the pelvic bones, body length and chest depth is somewhat slackened during the winter.

The course of normal growth in range cattle dictates autumn sale of surplus stock unless home-grown supplemental feed is cheap and abundant or the price to be obtained for the cattle the following spring is much higher per pound than can be had in the fall. Fall sale also lessens the danger of over-grazing in the late winter and early spring.

It is not considered likely that the slackened rate of growth during the winter period permanently stunts the cattle to any considerable extent but it does postpone their maturity to a later age than would be the case if they were kept under farm conditions and were fed liberally through the winter season.

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NORMAL GROWTH OF RANGE CATTLE*

JAY L. LUSH, J. M. JONES, W. H. DAMERON,
AND O. L. CARPENTER

Growth is a process familiar to all; yet it is hard to define. Many of the forces which guide and control it are still imperfectly known or perhaps not understood at all. An increase in weight is only one of the things which take place during growth. Some parts of the body grow more rapidly than others and this leads to changes in shape, which are just as truly a part of normal growth as is increase in weight. If a 70-pound calf were to grow to be a 1000-pound three-year-old steer while still keeping all parts of its body in the same proportion to each other as they were the first month after birth, it would be a monstrous sight indeed. As compared to the grown cow or steer, the calf is big-headed, leggy, tall, narrow, slender, and thinly muscled but the changes by which it assumes the form of the mature animal come about so gradually and naturally that they are hardly noticed at all. Some of these changes go on while the animal is actually losing weight, as when the weaned calf continues to grow in height and in bone measurements during its first winter even though it may actually weigh less in the spring when grass comes than it did at weaning time the previous fall. On the other hand growing and fattening are usually considered as different processes. An old cow which is thin in the spring, but which puts on two or three hundred pounds of fat during the summer would scarcely be considered to have "grown" and yet her weight would have increased very much.

The causes of growth are just as intricate as the forms of growth. Naturally the feed supply is the first thing considered as a cause of growth and it is the cause which is usually most nearly under control. Diseases or minor differences in health are just as obvious in controlling growth as are changes in the feed supply. Differences in the inheritance with which the animal starts life also play their part; else why should certain breeds and species of animals grow larger in the same pastures than others do? Why does an animal cease growing when it reaches an age or a size which we call "maturity"? Why should a sheep stop growing when it is around two or three years old and weighs 150 to 200 pounds while a cow in the same pasture will grow at least until she is five or six years old and may easily reach a weight of 1000 or 1200 pounds? Why do the bones of the head grow so much more rapidly during the first year of life than the ribs or the bones of the pelvis do?

*E. M. Peters, the first superintendent of Substation 14, was largely responsible for starting the studies of cattle at this substation. To him and to E. W. Thomas, the next superintendent, is expressed acknowledgment for their helpful suggestions and stimulating interest.

These facts have been a part of our everyday experience so long that most of us long ago ceased to wonder why they were so. The mechanism and the forces which control and regulate growth are so intricate that the answers to many of these questions are still in some doubt although many physiologists have worked upon them and many technical papers have been written about the details involved.

SCOPE OF THIS BULLETIN

This bulletin tells the story of how cattle grow while on the range so far as weights and measurements taken by the Texas Agricultural Experiment Station can describe that growth. The data come from Substation No. 14, which was established in 1915 primarily to study the problems of the range livestock industry. This substation was first stocked with cattle by the purchase of some high-grade Hereford yearling heifers in 1917. These heifers probably had something like three to five top-crosses of Hereford blood, although individual pedigrees had not been kept and we cannot be sure of the exact percentage of Hereford blood which they carried. They were of good Hereford type and most of them could hardly be distinguished from pure Herefords. Two showed black color around their eyes. A few others had abnormally large or small amounts of white markings. The first bulls used by the Station were registered Herefords. Beginning in 1920, a study of Brahman cattle and Brahman crosses was begun. Purebred Brahman bulls could not be obtained, but a three-quarter-blood Brahman was used for three years, then a "sixty-one sixty-fourths" Brahman bull was used for four years, and then a bull with about fifteen-sixteenths Brahman blood was used. Each year half of the cows were bred to a Hereford bull and half to a Brahman. The calves by the Brahman bull thus contained a little less than half Brahman blood and are hereafter called "first-cross Brahman-Herefords." The males were all castrated and fattened as steers. Many of the first-cross heifers were kept and bred to the Hereford bull. They thus produced calves containing a little less than one-quarter of Brahman blood. Such calves are hereafter called "back-crosses by Hereford sires."

A definite schedule of weighing the cattle was begun with the calves born in 1921. This schedule provided for weighing eight times per year at intervals of about six and a half weeks all cattle under 30 months old. Older cattle were weighed less frequently. The calves were weighed at birth or as soon afterward as they could be moved to the scales. A very few were as much as three days old when this first weight was taken. All were weighed about the first of June, middle of July, first of September, middle of October, first of December, middle of January, first of March, middle of April, and so on until they were 30 months old or were sold. Most of the steers were transferred to fattening pens before they were this old. The heifers were bred to calve at about 36 to 38 months of age. Thirty months was selected as the final weighing age for young stock because after this age the weights of some of the heifers bred earliest would begin to be noticeably affected by pregnancy.

This schedule of weighing is being continued. The weighing dates varied slightly but those supposed to be taken on the first of the month were usually completed before the fifth while those supposed to be taken at the middle of the month were usually taken between the 13th and 20th. Through oversight, one weighing date was missed entirely for the calves born in 1923 and another for the heifers born in 1927. A few individual animals were sometimes missed at other weighing dates. Weighing usually extended over at least two days. Each animal was weighed individually except for about half of the Herefords born in 1921, which were weighed in a group during their first year.

Beginning in 1922 a rather extensive series of body measurements was taken of cattle of all ages but more especially of the younger ones. The primary object of these measurements was to obtain exact descriptions of the differences between the Hereford cattle and their crosses with the Brahman breed. The inheritance of these differences was being studied. For various reasons these measurements were first made less frequently and then finally were discontinued entirely. Each animal was weighed far more frequently than it was measured. However, several groups of animals were measured four to six times at intervals of three to seven months and these measurements help very much in explaining many of the weight changes and in showing some of the features of growth which are not very well described by weight changes.

The only other publication which has come to our attention dealing especially with the weight changes of cattle on the range is United States Department of Agriculture, Department Bulletin No. 1394, "Normal Growth of Range Cattle," published in January, 1926, and written by A. B. Clawson. This is a study of pasture weights of cattle during the grazing season from about June 1st to about October 1st on summer range at the Salina Station in Utah. No records were kept for the remainder of the year. The animals were mostly loaned from the neighboring ranches and were replaced with different individuals for the studies of the following year. No measurements were taken. The data cover nine years and involve a total of 108 animals. The cattle showed a rapid weight increase in the early part of the grazing season, the rate of increase falling off as the season advanced. So far as the Texas data cover the same season of the year and cattle of the same age, they are essentially in agreement with the findings published in this Bulletin. The Oregon, Kansas, and West Virginia Stations have published* studies of the summer gains of steers on pasture following different methods of wintering. The experiments at the West Virginia Station were in cooperation with the United States Department of Agriculture.

The cattle on the Texas Station were managed just as they are man-

*Oregon Agricultural Experiment Station Bulletin 224; Kansas Agricultural Experiment Station, Circular 105, and various printed reports prepared for cattlemen's meetings at the Fort Hays Branch Station; West Virginia Agricultural Experiment Station Bulletins 186, 190, 191, and 218; United States Department of Agriculture, Department Circular 408 and a technical bulletin now in press.

aged on the private ranches in that region (Sutton and Edwards counties) except that the Station cattle are gathered up more often for weighing and other observations. A detailed description of the region and of the type of ranching may be found in Texas Bulletin No. 297. Grazing is year-long. The average annual rainfall is 20 to 25 inches, most of which falls from April to October. No supplemental feeding is practiced except late in severe winters. The supplemental feed when given is usually one to two pounds of cottonseed cake per head per day. During the eight winters covered by these data, supplemental feeding was necessary in two winters and was thought advisable in three other winters at least for the cows which were soon to calve. Spineless cactus was fed in small amounts and proved to be a very useful forage plant for the region. Snow fell occasionally during the winters but very rarely lay on the ground more than a day or two. Supplemental feeding when necessary was so not because of snowfall but because of drouth and scanty pastures the preceding summer and fall, or because of the absence of winter and early spring rains, which normally bring on the green vegetation in late winter and early spring. The eight winters included in this study were about an average sample of the weather to be expected in this region. No real extreme drouths occurred during this time, but such are rare anyhow.

CHANGES IN LIVE WEIGHT

Table 1.—Averages of all available weights, grouped by sex and by breeding.

	All cattle		All steers		All heifers		All Herefords		All first-cross Brahman-Herefords		All back; crosses	
	No'	Average	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average
Dam's weight	502	827.3	258	816.5	244	838.8	168	835.6	226	823.0	108	823.5
Birth date	502	Mar. 30	258	Mar. 30	244	Mar. 29	168	April 3	226	April 2	108	Mar. 17
Birth weight	502	73.8	258	76.4	244	71.0	168	75.7	226	74.7	108	68.8
June 1-5	474	200.7	245	206.6	229	194.3	159	194.8	207	187.7	108	234.2
July 13-20	515	267.1	263	273.8	252	260.2	185	260.5	223	252.6	107	308.8
September 1-5	521	341.8	265	348.4	256	335.0	188	329.1	225	325.0	108	398.8
October 13-20	519	390.8	263	400.4	256	380.9	188	372.3	225	379.1	106	448.3
December 1-5	329	410.3	121	424.0	208	402.3	145	395.0	137	410.4	47	457.1
January 13-20	330	409.1	122	423.7	208	400.5	145	392.5	138	410.4	47	456.5
March 1-5	330	388.2	122	396.5	208	383.4	145	365.4	138	393.3	47	443.8
April 13-20	328	418.0	120	414.8	208	419.9	144	393.4	137	419.8	47	487.9
June 1-5	291	513.1	93	523.7	198	508.1	126	484.4	127	523.2	38	574.3
July 13-20	291	561.7	93	574.0	198	555.9	126	542.7	127	568.1	38	603.4
September 1-5	291	601.4	93	613.7	198	595.7	126	572.1	127	612.5	38	661.8
October 13-20	291	637.5	93	654.9	198	629.4	126	610.4	127	651.9	38	679.8
December 1-5	194	644.9	24	679.8	170	639.9	100	632.0	78	655.3	16	674.7
January 13-20	194	631.3	24	658.7	170	627.4	100	617.1	78	643.4	16	661.4
March 1-5	193	602.0	24	614.5	169	600.2	100	581.5	78	621.3	15	638.4
April 13-20	189	626.3	24	647.4	165	623.2	98	597.6	76	655.7	15	664.3
June 1-5	165	743.7	24	768.9	141	739.4	89	717.0	72	772.3	4	823.0
July 13-20	166	793.3	24	821.8	142	788.4	89	777.7	73	812.1	4	*795.8
September 1-5	154	815.8	24	784.4	130	821.6	83	794.3	67	836.1	4	919.5
October 13-20	82	853.1	24	862.7	58	849.2	36	820.3	42	879.1	4	875.8

*One animal was suffering from a severe attack of screwworms at the July weighing date and this figure is accordingly low.

Table 2.—Averages of all available weights, grouped by year of birth.

	Calves born in																	
	1921		1922		1923		1924		1925		1926		1927		1928		1929	
	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average	No.	Average
Dam's weight	29	734	47	776	36	871	54	819	63	819	78	824	46	823	61	884	88	846
Birth date	29	April 1	47	April 1	36	April 17	54	Mar. 12	63	Mar. 21	78	April 13	46	Mar. 22	61	Mar. 23	88	Mar. 30
Birth weight	29	75	47	72	36	77	54	72	63	72	78	75	46	67	61	74	88	77
June 1-5	49	205	46	172	.....	.....	54	201	63	188	76	186	43	218	60	234	83	203
July 13-20	49	292	47	268	35	238	54	295	60	252	76	228	46	264	60	299	88	271
September 1-5	51	334	47	348	35	319	54	361	63	311	77	289	46	350	60	392	88	370
October 13-20	51	372	47	417	35	384	54	431	61	367	77	304	46	394	60	459	88	410
December 1-5	51	383	47	420	35	408	54	431	28	405	40	326	45	439	29	483	.....	.....
January 13-20	51	356	47	441	35	415	54	435	28	392	40	323	46	442	29	479	.....	.....
March 1-5	51	319	47	411	35	392	54	415	28	379	40	313	46	438	29	454	.....	.....
April 13-20	50	347	47	460	35	410	53	375	28	414	40	385	46	486	29	503	.....	.....
June 1-5	23	427	47	532	35	499	53	484	28	530	40	473	37	562	28	602	.....	.....
July 13-20	23	540	47	559	35	590	53	537	28	538	40	509	37	603	28	639	.....	.....
September 1-5	23	574	47	619	35	568	53	565	28	555	40	584	37	673	28	683	.....	.....
October 13-20	23	627	47	648	35	626	53	623	28	577	40	589	37	698	28	721	.....	.....
December 1-5	23	635	47	676	20	629	25	652	28	578	40	648	11	704	.....	.....	.....	.....
January 13-20	23	641	47	660	20	639	25	617	28	555	40	637	11	682	.....	.....	.....	.....
March 1-5	23	617	47	608	20	611	24	588	28	555	40	605	11	669	.....	.....	.....	.....
April 13-20	23	622	46	643	20	544	22	636	28	626	39	623	11	707	.....	.....	.....	.....
June 1-5	23	757	40	774	20	666	23	736	28	744	20	737	11	774	.....	.....	.....	.....
July 13-20	23	783	41	836	20	764	23	744	28	753	20	826	11	854	.....	.....	.....	.....
September 1-5	23	827	41	820	19	799	23	784	28	831	20	826	.....	.....	.....	.....	.....	.....
October 13-20	.....	.....	24	863	.....	.....	.....	.....	27	810	20	880	11	888	.....	.....	.....	.....

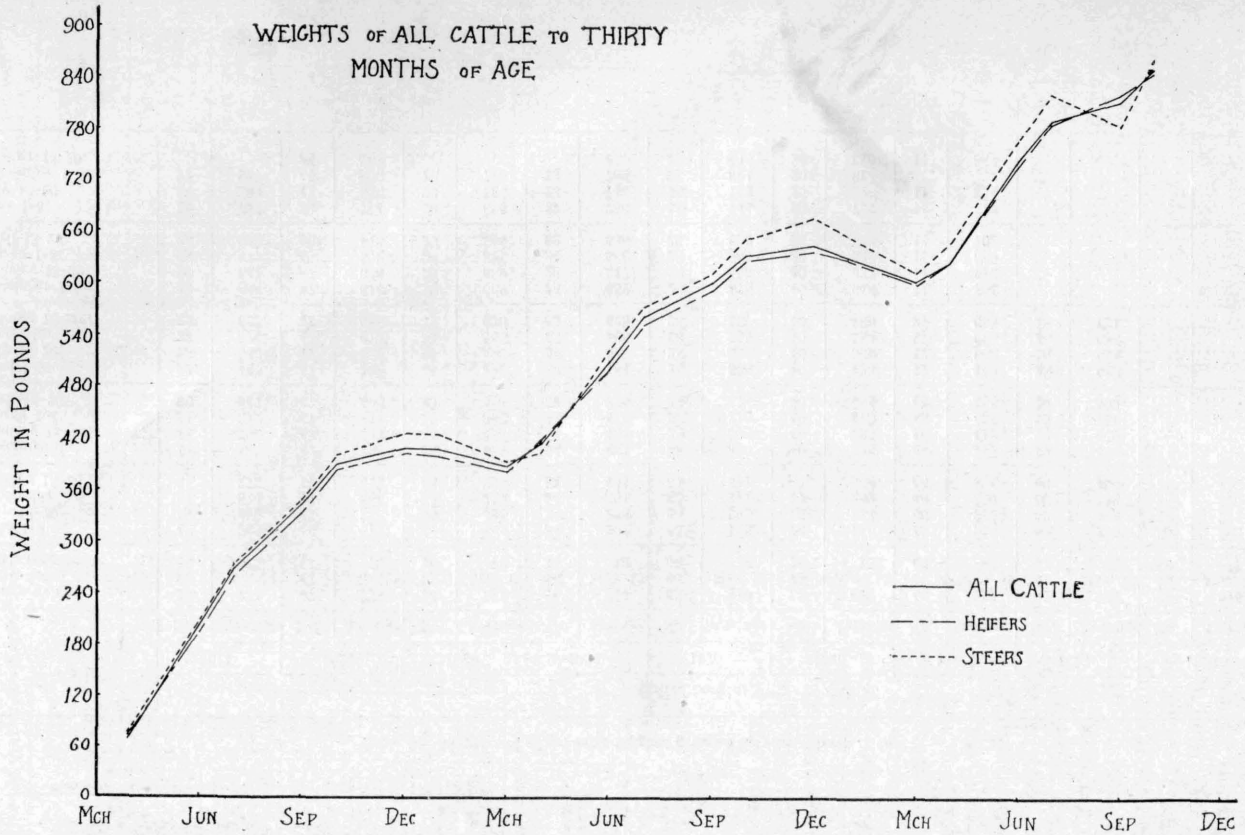

Figure 1. Average growth curves of range cattle. (Based on all available weights as shown in Table 1.) The peculiarly cyclic nature of these growth curves is caused by the changing supply of forage at different seasons and is not inherently necessary. The difference between the weights of steers and heifers, although small, is consistent and probably represents a real fundamental difference in the weights of the sexes.

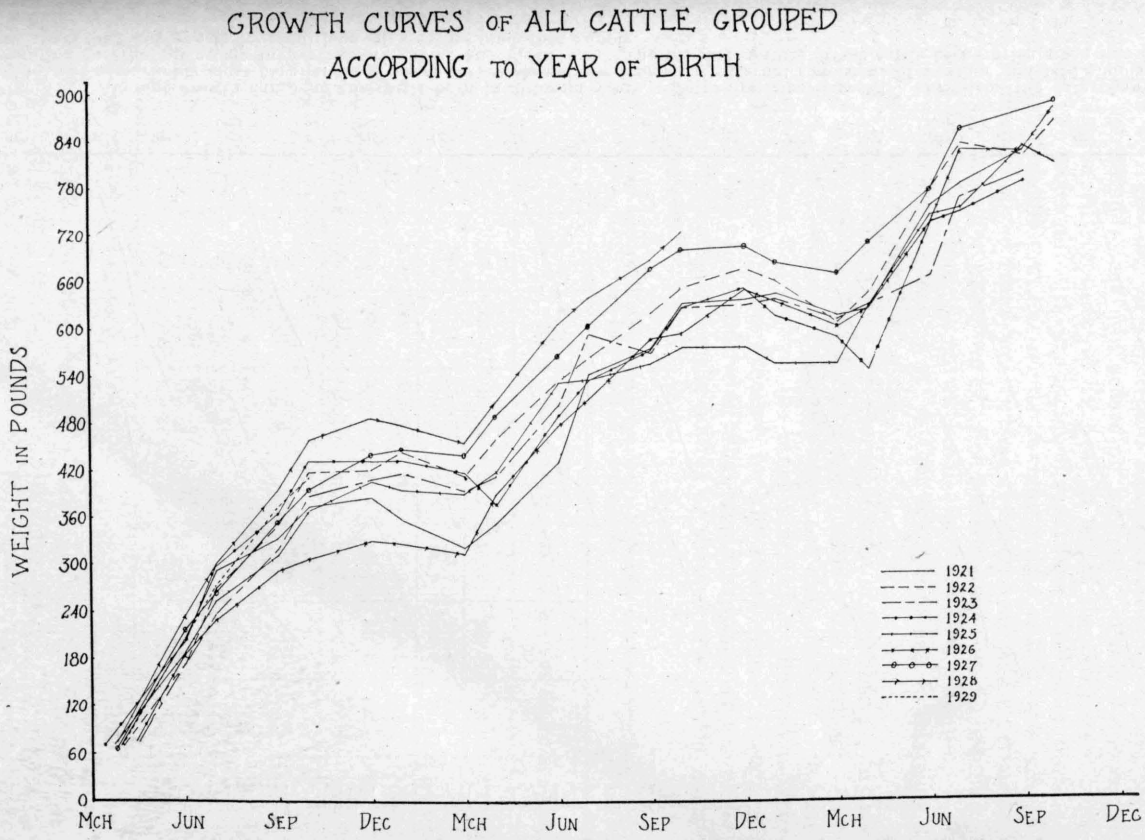

Figure 2. Average growth curves of the cattle born in different years. Ages are superimposed. (Based on the data shown in Table 2.) The large amount of variation here shows how little weight depends on age alone. The amount and kind of forage available in different years greatly affect the average weight of the cattle at any given age.

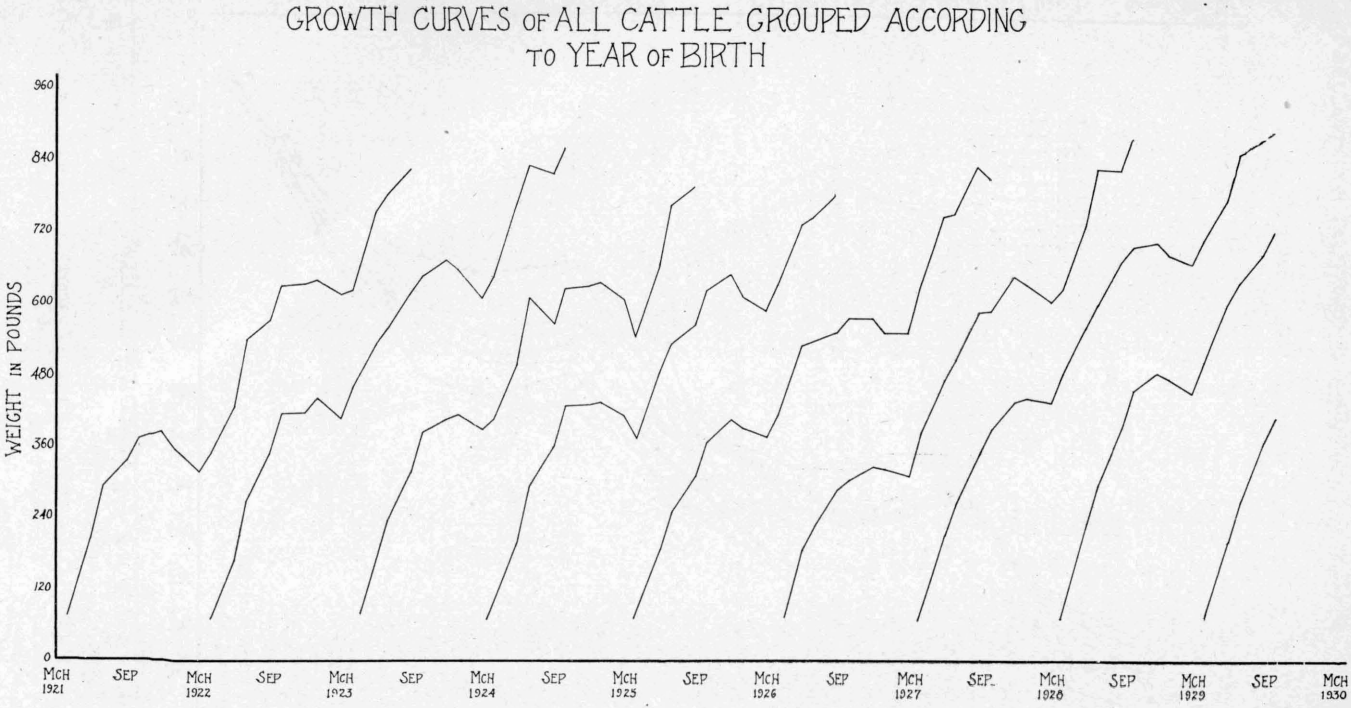

Figure 3. Average growth curves of the cattle born in different years. Dates are superimposed. (Based on the data shown in Table 2.) The remarkably close parallelism of these curves shows how important external conditions of weather and feed supply are in accounting for the variations in average weight at any given age. The intrinsic nature of the cattle born varies much less from year to year than the extrinsic conditions of weather and feed supply.

Table 1 shows the average weights of all cattle weighed. They are shown as averages for all cattle and also as averages for the cattle grouped according to sex and according to breed. Table 2 shows the same data grouped according to the year in which the cattle were born. In these two tables all cattle are included regardless of whether they had been weighed at the previous regular weighing date or had been missed. The numbers changed from time to time as cattle were sold or occasionally one was missed or was obviously sick when rounded up for weighing. In these two tables there is shown beside each average the number of weights which are included in it, so that the reader can estimate in a general way how reliable the average is.

Figure 1 shows at a glance the average course of the changes in live weight up to two and one-half years of age. Besides the heavy solid line for all data, the averages for the two sexes are also shown. Only one year's crop of steers was kept on the range much after eighteen months of age and consequently the averages for the steers from that age on may be a little less representative of what would happen over a number of years than the averages for the heifers or the averages for the steers at younger ages are.

Table 3.—Average weights of all calves which were weighed at birth and at each regular weighing date until October of their first year.

	No. included	Dam's weight	Birth date	Birth weight	June 1-5	July 13-20	Sep. 1-5	Oct. 13-20
Total	444	823.3	Mar. 26	73.5	199.9	269.7	347.2	395.7
All steers	230	811.4	Mar. 26	76.2	205.7	276.8	353.7	405.2
All heifers	214	836.2	Mar. 26	70.7	193.6	262.0	340.3	385.4
All Herefords	134	826.8	Mar. 28	75.4	190.6	258.4	332.1	372.9
All first-cross Brahman-Herefords	205	820.3	Mar. 29	74.6	188.0	257.0	329.8	383.3
All back-crosses by Hereford sires	105	825.0	Mar. 17	69.1	235.0	308.8	400.5	448.9
All calves born in:								
1921	25	734	April 8	75	187	271	322	364
1922	46	776	Mar. 30	71	172	270	349	419
*1923								
1924	54	819	Mar. 13	72	201	295	361	431
1925	58	825	Mar. 21	73	189	250	310	367
1926	75	823	April 10	75	188	229	293	308
1927	43	810	Mar. 16	66	218	274	361	405
1928	60	888	Mar. 22	74	234	299	392	459
1929	83	839	Mar. 26	78	203	279	380	419

*None of the 1923 calves were weighed at the June date.

Figures 2 and 3 show at a glance the data in Table 2. The weights are averaged separately for calves born in different years. In Figure 2, weights taken at a given age are shown at points on the same vertical line. In Figure 3, weights taken on a given date are shown at the points on the same vertical line. Thus in Figure 2 the weights of cattle of nearly a given age are scattered along the same vertical line but the weather and pasture conditions under which those weights were taken

Table 4.—Average weights of all calves which were weighed on every regular weighing date from September of their calf year to October of their yearling year.

	No. included	Sept. 1–5	Oct. 13–20	Dec. 1–5	Jan. 13–20	Mar. 1–5	April 13–20	June 1–5	July 13–20	Sept. 1–5	Oct. 13–20
Total	290	334.1	387.0	408.7	410.6	390.6	419.3	513.6	562.3	602.0	638.0
All steers	92	348.5	412.7	431.1	441.9	418.5	432.1	525.5	576.2	615.5	656.6
All heifers	198	327.4	375.1	398.3	396.1	377.6	413.3	508.1	555.9	595.7	629.4
All Herefords	126	331.5	379.5	395.4	396.6	372.0	398.1	484.4	542.7	572.1	610.4
All first-cross Brahman-Herefords	126	325.4	385.0	410.2	414.2	398.0	425.2	524.6	569.6	613.8	653.1
All back-crosses by Hereford sires	38	371.3	418.7	448.1	445.1	427.4	469.7	574.3	603.4	661.8	679.8
All calves born in:											
1921	23	321	359	369	343	311	332	427	540	574	627
1922	47	348	417	420	441	411	460	532	559	619	648
1923	35	319	384	408	415	392	410	499	590	568	626
1924	53	360	428	428	433	413	375	484	537	565	623
1925	28	311	364	405	392	379	414	530	538	555	577
1926	40	281	292	326	323	313	385	473	509	584	589
1927	36	346	390	430	438	430	474	568	609	680	703
1928	28	376	440	482	476	451	502	602	639	683	721

Table 5.—Average weights of all cattle which were weighed on every regular weighing date from July when yearlings to September when two-year-olds.

	No. included	July 13–20	Sept. 1–5	Oct. 13–20	Dec. 1–5	Jan. 13–20	Mar. 1–5	April 13–20	June 1–5	July 13–20	Sept. 1–5
Total	152	547.2	581.7	619.6	642.0	628.4	600.3	623.9	742.0	790.3	817.7
All steers	24	563.3	618.5	648.0	679.8	658.7	614.5	647.4	768.9	821.8	784.4
All heifers	128	544.1	574.8	614.2	634.9	622.7	597.6	619.5	737.0	784.4	824.0
All Herefords	83	539.2	568.6	609.9	631.1	617.9	582.5	596.0	714.3	773.9	794.3
All first-cross Brahman-Herefords	65	553.7	596.0	631.4	656.6	643.5	622.5	656.6	772.4	810.8	841.4
All back-crosses by Hereford sires	4	607	620	628	629	601	608	673	823	796	920
All calves born in:											
1921	23	540	574	627	635	641	617	622	757	783	827
1922	40	570	629	662	690	674	624	656	774	839	823
1923	19	587	564	633	630	639	611	544	665	764	799
1924	22	517	543	595	640	604	581	636	736	746	791
1925	28	538	555	577	578	555	555	626	744	753	831
1926	20	518	592	600	657	642	608	621	737	826	826

often were very different for cattle born in different years. In Figure 3, the weights on the same vertical line were taken under the same weather and pasture conditions but the cattle were of different ages. The lines in Figure 3 are very distinctly more parallel than those in Figure 2. This shows the greater importance of weather and pasture conditions in determining the changes in these live weights as compared with any inward tendency there may have been for cattle of a certain age to grow at a certain rate.

In Tables 3, 4, and 5, all cattle which were weighed irregularly are excluded. This slightly reduces the number of weights included in those averages but removes the objection that an observed change from one date to another might have been affected by the inclusion of unusually heavy or unusually light animals on one date but not on the other. Table 3 shows the averages for all calves which were weighed at birth and also at the first four regular weighing dates. They are also averaged by sex, by breed, and by year born. Figure 4 shows these averages by breeds from birth until mid-October of the calf year.

The steer calves of the 1925, 1926, and 1928 crops were put in feedlots before their first winter. Also, the 1921 steers were shipped to another Substation when about one year old. These together with the 1929 calves of both sexes are necessarily absent from Table 4 and very materially reduce the numbers included in it, especially the numbers of steers. Table 4 shows the average weights of all those cattle which were weighed on every regular weighing date from September when they were about five or six months old until October when they were about nineteen months old. Roughly it shows the course of growth in weight from shortly before weaning time (usually late November) until about a year after weaning and includes the first winter and the second summer on the range. Figure 5 shows these averages by breeds.

All the remaining steers except those born in 1922 were taken to feedlots in the fall of their yearling year. The 1927 heifers, through oversight, were not weighed in September of their two-year-old year. These and the 1928 heifers necessarily had to be left out of Table 5, which shows the course of growth in weight through the second fall and winter and the third spring and summer. Figure 6 shows these averages by breeds. The number of back-crosses is too small to be very dependable. Also the steers included were all from the 1922 calf crop. The heifers, however, came from six different calf crops and one may probably place considerable confidence in their being fairly representative.

As far as sex is concerned, the curves of changes in weight are practically parallel. The steer calves grow a little faster than the heifer calves and the difference between them is large enough and consistent enough that it can hardly be regarded as accidental.

The three different kinds of breeding show almost parallel changes in weight. The first-cross calves weigh a little less at birth than the Herefords and this corresponds to the impression which one gets from looking at them and studying them closely. By October the first-crosses are

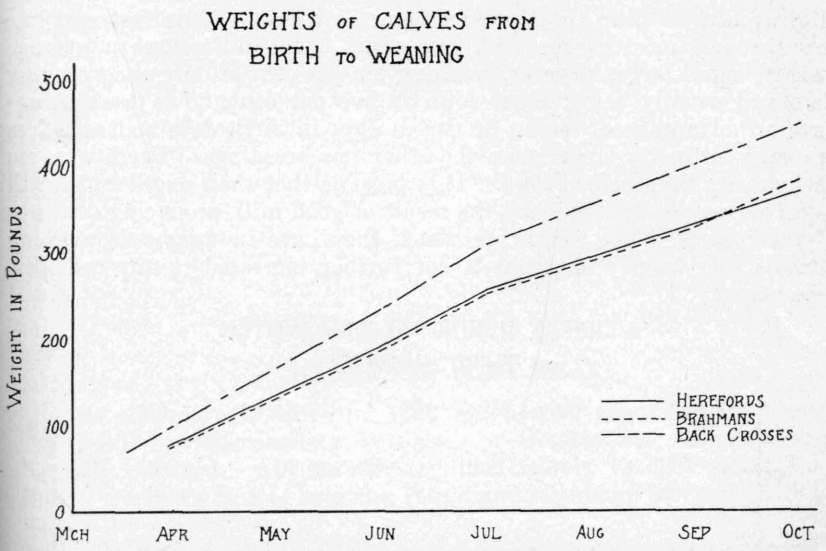

Figure 4. Average weights of all calves which were weighed on every regular weighing occasion from birth to October of their calf year. (Based on data shown in Table 3.) The growth curves are practically parallel and the calves are growing nearly as fast in October as at any previous time. They were still unweaned in October when these curves end.

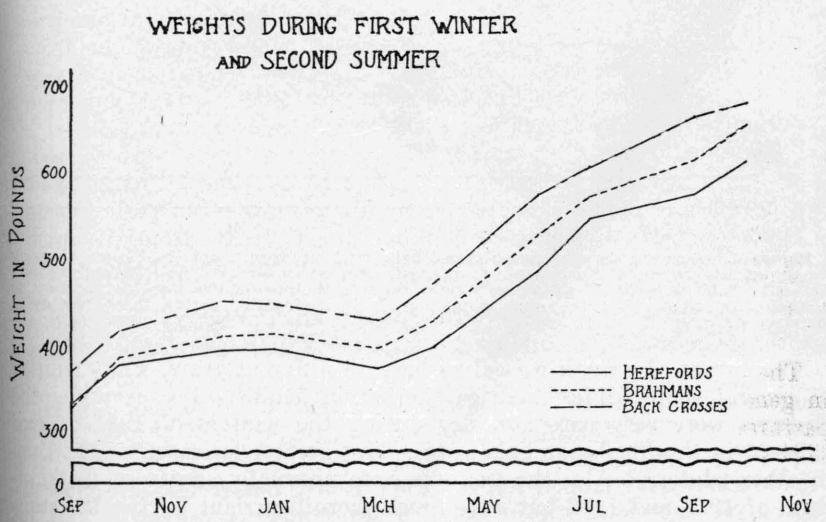

Figure 5. Average growth curves of all calves which were weighed on every regular weighing date from September of their calf year to October of their yearling year. (Based on data shown in Table 4.) The period of feed scarcity begins soon after October and is severe through the winter months. Many of the calves actually weigh less in March than they did in the preceding October. Growth in weight is resumed at a rapid rate when grass comes again in the spring.

slightly heavier than the Herefords and they gain a little faster or lose less through most of the next two years. The difference in average weights is not large, however, reaching ten per cent at only one weighing date and usually being about four or five per cent. The back-crosses have an advantage of eleven or twelve days in birth date and as calves are very distinctly larger than the other two breedings. There were no back-crosses born before 1924. It is possible that their excellent growth as calves may be in large part the result of good milk-producing qualities of their dams. The advantage which they have in weight at weaning time is very largely kept but is not further increased to any considerable extent.

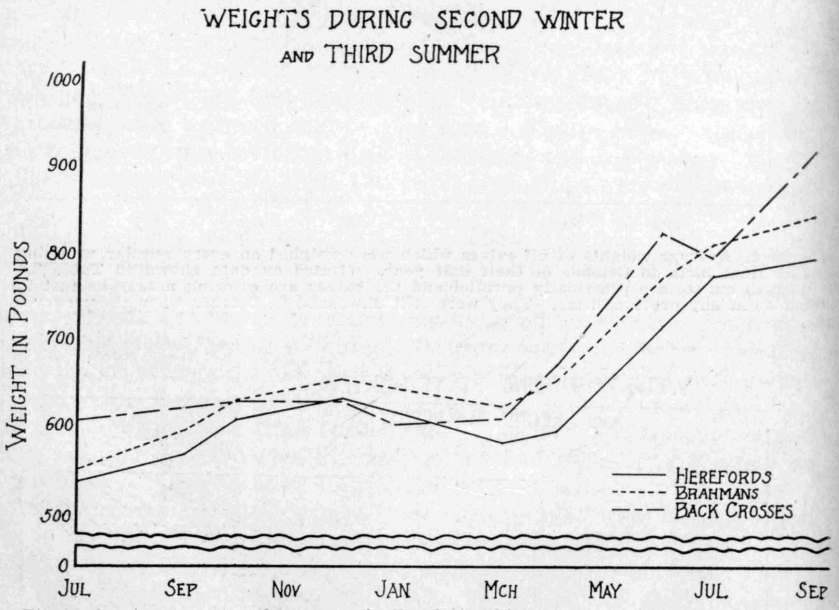

Figure 6. Average growth curves of all calves which were weighed on every regular weighing date from July as yearlings to September as two-year-olds. (Based on data shown in Table 5.) Most cattle lose weight through their second winter just as they do in their first winter, but they gain more rapidly in their third spring than they do in their second spring.

The curves of growth for calves born in different years, while similar in general shape, differ from each other in details. For example, the pastures were very bare and dry during the winters of 1921-22 and 1924-25 in this region and the cattle show greater losses in weight than in other winters. Also the pastures were unusually scanty in the summers of 1925 and 1926 but were much more luxuriant during the summers of 1928 and 1929. The weights of the cattle in these years show the effects of these differences in pasture conditions.

All of these curves regardless of sex, breed, or year have been of the same general shape. All are characterized by exceedingly rapid in-

creases from about April until the middle of the summer. Then the rate of increase begins to slow down until it finally ceases altogether some time between October and January. There is nearly always an actual loss in weight some time between December first and the middle of April. Weights usually reach their low point in March (among the weighing dates used at this Station) but show only a small regain up to the middle of April. This characteristic shape of the curve of weight growth under this system of ranch management has a very important bearing on questions of when to sell and when supplementary feeding may pay and how much supplementary feeding should be done through the winter. But before these are considered let us look a little more carefully at these changes in weight to see what else has changed besides weight.

CHANGES IN BODY SHAPE

The year-old calf which in April weighs just about the same amount as it did in the preceding December or October has nevertheless very greatly changed. Anyone can see that merely by looking at it. In April the calf's hair is long and rough and stands up whereas in October

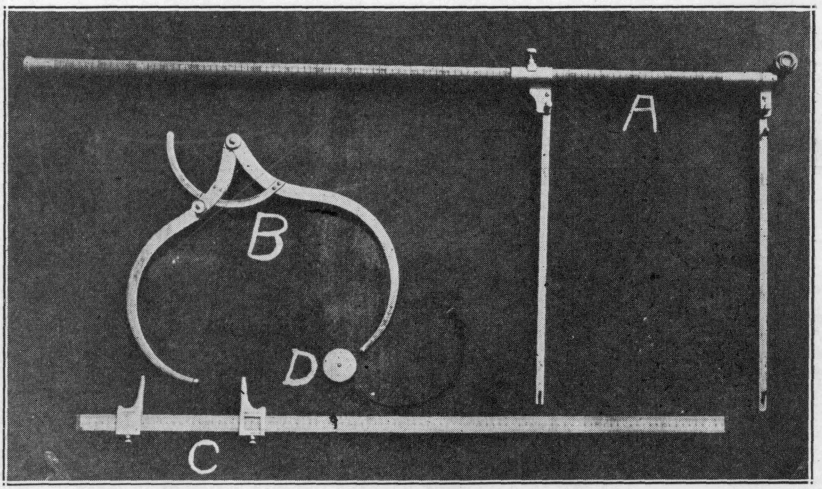

Figure 7. Instruments used for measuring steers and heifers. A, Cattle measuring standard with spirit level attached, Lydtins model. B, Caliper used for measuring pelvic region and for loin width. C, Caliper used for measuring length of head and width at eyes. D, Steel tape used for measuring girths and circumferences.

its hair is shorter and sleeker and gives it a general appearance of smoothness. During the winter the calf has grown taller and longer-bodied. Its head is bigger. In general, all of its bones have grown but the muscles seem to have shrunken and the evidences of fatness are nearly all gone. The circumference of the body is much decreased, specially in the region of the flank. The increase in the weight of bone and hide

Table 6.—Average measurements of Hereford steers born in 1922.

The average birth date was March 28, 1922. All measurements except dewlap area are in centimeters. (One inch is about two and a half centimeters.) The location of the measurements is shown in figures 7 and 8.

Measurement	June 4, 1922	Sept. 2, 1922	Feb. 20, 1923	Sept. 4, 1923	Mar. 4, 1924	Sept. 4, 1924
Width at eyes	15.3	17.6	19.0	20.5	21.1	22.1
Length of head	29.1	35.8	38.6	42.4	44.6	47.1
Width at loin	16.5	21.1	23.5	27.1	28.1	30.5
Width at hooks	22.2	29.5	33.2	38.3	39.3	42.9
Width at pelvis or thurls	25.3	30.2	33.4	36.7	38.0	40.7
Width at pin bones	14.8	18.4	19.9	22.5	23.0	25.6
Length of pelvis	29.5	35.8	38.8	43.3	44.9	47.2
Muzzle circumference	29.2	32.9	35.5	39.2	39.2	41.3
Cannon circumference	13.3	14.8	15.4	16.9	17.1	18.3
Paunch girth	107.6	148.0	153.2	185.5	170.0	189.2
Flank girth	99.9	127.3	131.8	153.5	145.5	160.9
Chest girth	100.3	121.9	131.2	150.0	151.3	164.0
Width of chest	23.1	27.2	27.8	33.6	31.8	35.3
Depth of chest	.....	44.2	49.0	54.9	56.5	62.3
Height over withers	78.7	91.3	100.1	107.2	111.9	118.2
Height over hips	84.4	95.5	103.7	111.7	116.4	122.3
Height at elbow	49.5	57.9	61.7	66.0	69.1	72.5
Height at knee	27.1	29.4	32.1	32.8	34.2	35.1
Length of body	83.0	103.7	113.2	126.4	130.5	138.6
Least height at sternum	39.6	44.0	47.2	47.3	48.9	50.1
Greatest height at sternum	43.1	47.1	51.8	51.7	55.3	56.9
Length inside ear	12.1	13.5	14.1	15.2	15.6	16.1
Dewlap area (square inches)	9.6	17.0	19.6	15.3	17.4	28.1

Table 7.—Average measurements of Hereford heifers born in 1922.

The average birth date was March 24, 1922. All measurements except dewlap area are in centimeters. (One inch is about two and a half centimeters.) The location of the measurements is shown in figures 7 and 8.

Measurement	June 4, 1922	Sept. 2, 1922	Feb. 20, 1923	Sept. 4, 1923	Mar. 4, 1924	Sept. 4, 1924
Width at eyes	15.1	17.3	18.6	20.0	20.6	21.8
Length of head	29.0	34.7	38.2	41.4	43.5	45.8
Width at loin	16.6	21.4	23.8	27.8	28.8	33.2
Width at hooks	22.3	30.2	34.1	39.4	41.3	47.4
Width at pelvis or thurls	25.4	30.4	33.2	36.7	38.4	41.8
Width at pin bones	15.1	18.7	20.0	23.9	24.8	29.2
Length of pelvis	28.9	35.2	38.5	43.1	43.5	49.4
Muzzle circumference	28.8	32.3	35.3	38.1	38.4	40.0
Cannon circumference	12.5	14.1	14.6	16.1	16.1	17.3
Pauch girth	107.1	150.5	150.2	179.2	168.1	203.4
Flank girth	99.7	129.1	131.7	155.1	147.1	175.0
Chest girth	101.0	122.9	130.9	149.6	151.1	170.6
Width of chest	23.4	28.0	27.8	33.8	31.5	38.3
Depth of chest	.....	44.4	48.5	54.4	56.3	62.6
Height over withers	78.0	90.6	99.3	105.4	110.4	116.6
Height over hips	84.1	95.3	104.4	111.0	114.9	120.1
Height at elbow	49.6	56.8	61.1	65.1	67.1	69.2
Height at knee	26.9	29.4	31.8	32.4	33.0	33.4
Length of body	82.9	103.2	112.2	124.0	130.3	142.5
Least height at sternum	38.4	43.2	47.5	46.2	48.6	46.8
Greatest height at sternum	42.6	46.5	51.2	51.4	54.7	52.5
Length inside ear	11.9	13.2	13.9	14.8	15.2	15.7
Dewlap area (square inches)	9.3	14.2	20.6	11.8	16.3	13.2

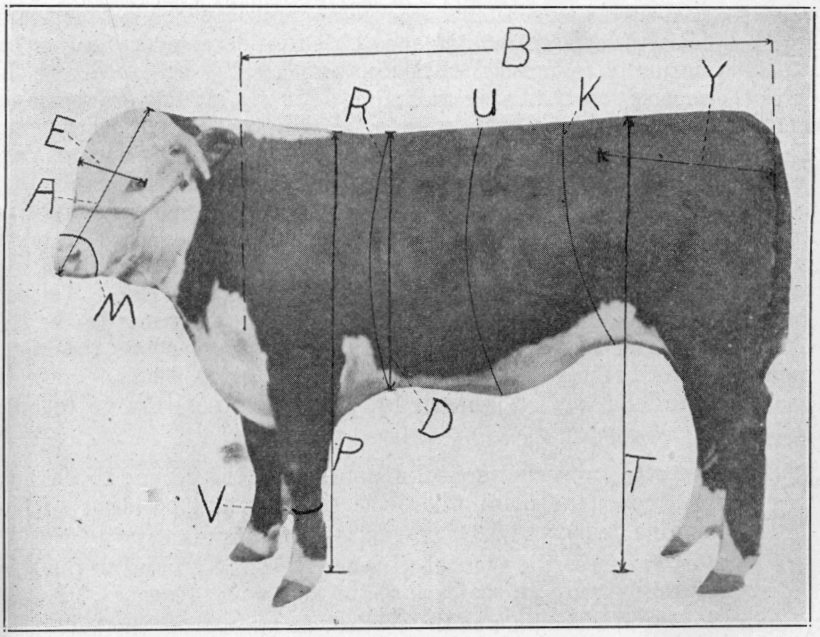

Figure 8. Side view of Hereford steer showing the location of the various measurements studied. A, Length of head. B, Length of body. D, Depth of chest. E, Width at eyes. K, Flank girth. M, Muzzle circumference. P, Height over withers. R, Chest girth. T, Height over hips. U, Paunch girth. V, Cannon circumference. Y, Length of pelvis.

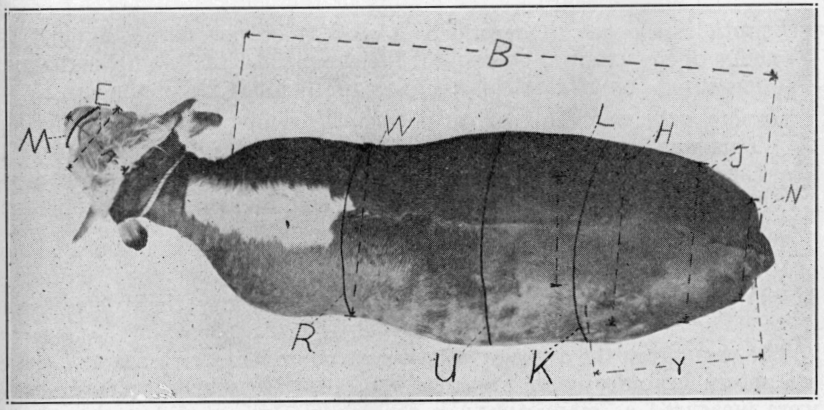

Figure 9. Top view of Hereford steer showing the location of the various measurements studied. A, Length of head. B, Length of body. E, Width at eyes. H, Width at hooks. J, Width at pelvis or thurls. K, Flank girth. L, Width at loin. M, Muzzle circumference. N, Width at pin bones. R, Chest girth. U, Paunch girth. W, Width of chest. Y, Length of pelvis.

has been offset by a decrease in the weight of fat in the calf. The weight of true muscle substance (protein) probably has not decreased and may have increased a little but the considerable amount of fat which is normally in muscles has been very greatly decreased and this gives the muscles on the living animal a distinctly shrunken appearance. That these changes take place we have always known in a general way. The nature and the extent of them have been measured in various carefully controlled experiments by chemical and slaughter tests. On these cattle of the Texas Station under range conditions such tests were not applied but body measurements were made and their changes do tell us much about these changes in composition and in body shape which were taking place even while the live weight changed but little. Tables 6 and 7 show the average measurements at six different times in the lives of the steers and the heifers born in 1922. Figure 7 shows the instruments used in making these measurements. Figures 8 and 9 show the location of all but six of the measurements. Those six were taken as follows:

Height at elbow was the vertical distance from the ground to the point of the elbow (the point where the superior and posterior surfaces of the ulna join).

Height at knee was the vertical distance from the ground to the small bony protuberance on the back of the knee joint (carpus).

Least height at sternum was the vertical distance from the lowest part of the brisket to the ground. The caliper arm was placed snugly against the solid part of the brisket so that the measurement was not influenced by the amount of dewlap present.

Greatest height at sternum was the vertical distance from the ground to the highest point on the bottom of the chest.

Length inside ear. One end of a steel ruler was placed against the edge of the external opening of the ear nearest the head, the distance measured being from this point to the farthest tip of the ear.

Dewlap area was the total area, seen from one side, of the dewlap. This was estimated by the observer who used a ruler frequently to check his estimates. It is given in square inches. All other measurements are given in centimeters. (One inch = 2.54 centimeters.)

The March and February measurements were taken at about the time of year when the cattle were in the thinnest condition. The September measurements were taken when they were at nearly their fattest condition.

The changes in the averages of these measurements with age and season are shown graphically in Figures 10 to 13. No other groups of cattle were measured as many times as the 1922 calves were but three other groups of heifers were measured at four different ages and they are included in the graphs.

The measurements shown were all made on cattle which had no Brah-

man blood. In some measurements there appeared to be real breed differences. The Brahman measurements are therefore omitted lest they needlessly confuse the diagrams and obscure the real subject of this bulletin, which is the course of normal growth in range cattle. It is planned to treat of the differences found between Brahman and Hereford cattle in a later bulletin. Meanwhile the data from the high-grade

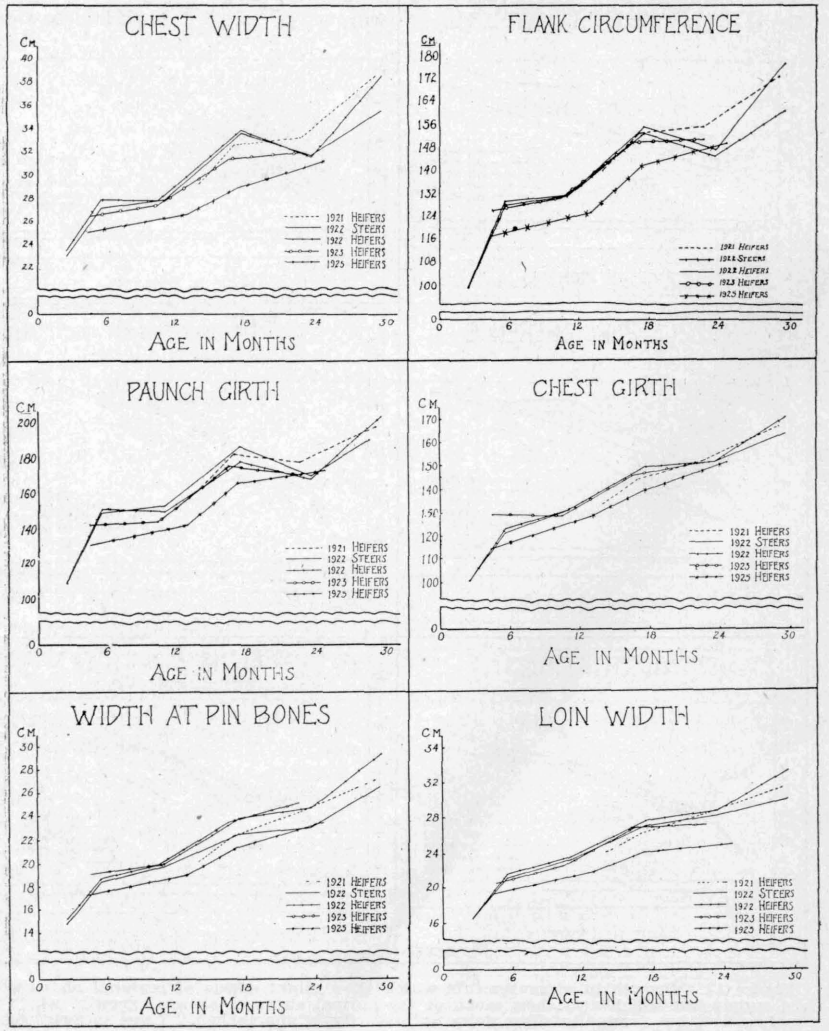

Figure 10. Growth in measurements which are very much affected by fatness and by the size of the digestive organs or "fill." Like weight, these measurements increase much more rapidly in the spring and summer than from September to March. Growth in these measurements is markedly influenced by the nutritional condition of the animal.

Herefords will have much more general interest and they alone are included here.

A previous study of changes in the measurements of steers during fattening* showed (as was of course to be expected) that certain measurements changed with fattening far more than others. Several kinds

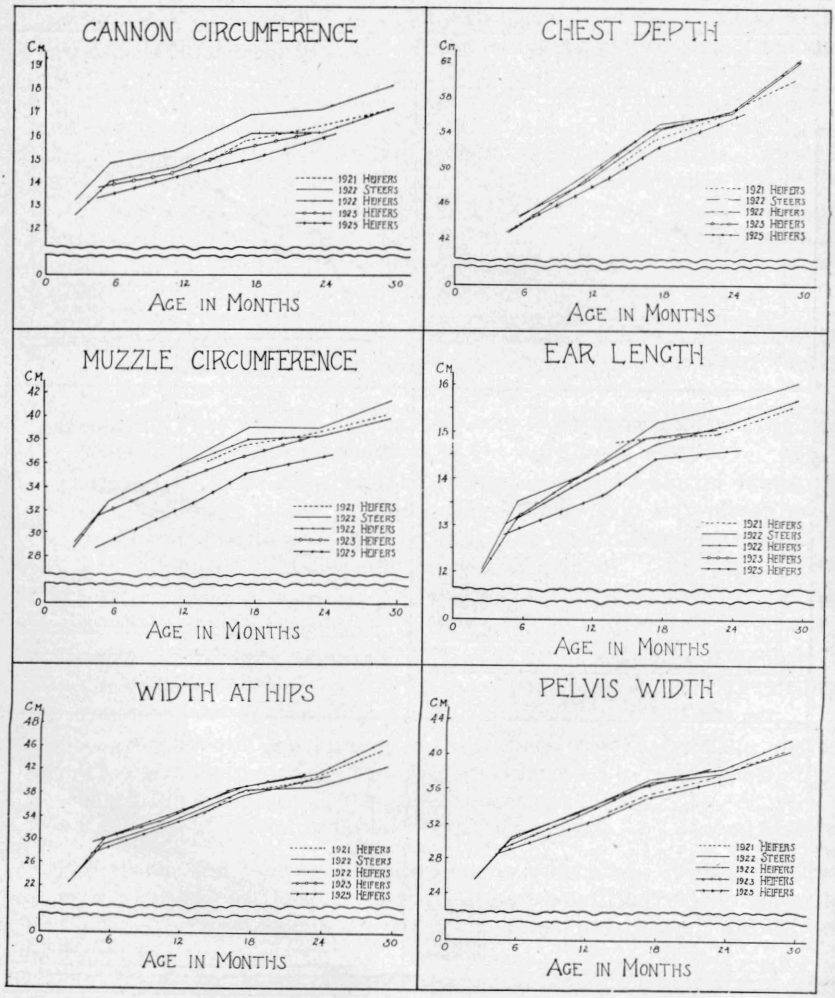

Figure 11. Growth in measurements which show slight effects of seasonal changes in feed supply but which also show much of the normal curve of skeletal growth, which is rapid at first but gradually slows down as maturity is approached. These measurements show a little of the cyclic growth which is so conspicuous in the weight growth of range cattle.

*Lush, Jay L. 1928. Changes of Body Measurements of Steers During Intensive Fattening. Texas Agricultural Experiment Station Bulletin No. 385.

of measurements included in the present bulletin were not taken on the fattening steers. Of the measurements taken on the steers, chest width was most increased during fattening with loin width and heart girth being next most increased. Other measurements which increased at a more rapid rate than live weight did were flank girth and width at hooks. The measurements which increased least rapidly during fattening were those of bony parts, such as the head, height at withers and height at hips, length of body, and circumference of cannon bone. The only measurements of bony parts which grew very rapidly during fattening were those

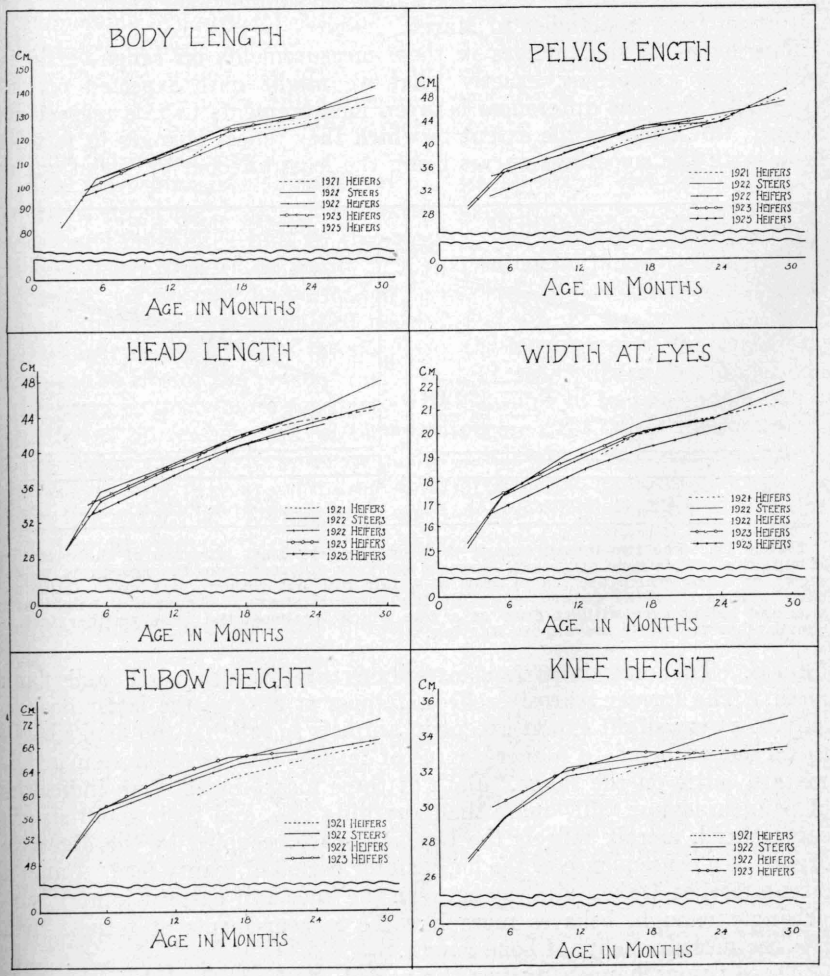

Figure 12. Growth in measurements which are very slightly affected by variation in the amount of feed available at different seasons. Only a trace of the cyclic growth so characteristic of growth in weight is to be seen here. The growth shown here is predominantly like that of cattle fed at a uniform rate the year around.

of the pelvic region, and this was attributed in large part to the relatively late maturity of that part of the body combined with the fact that many of the steers being fattened were less than a year old when the feeding began.

When the measurements of cattle on the range are studied, they are seen to fall into a series from one extreme represented by measurements like height over withers and height over hips, which show a regular change with age, to another extreme represented by measurements like width of chest and flank circumference, which show a very jagged line, increasing very greatly during the spring or summer, but very slowly or not at all from September to March.

The course of the changes in these measurements on range cattle is, with a few exceptions, exactly what we might have expected on the hypothesis that the differences between measurements in this respect are mainly differences in the extent to which they reflect changes in fatness, those with the smoothest curves being the least affected by variations in

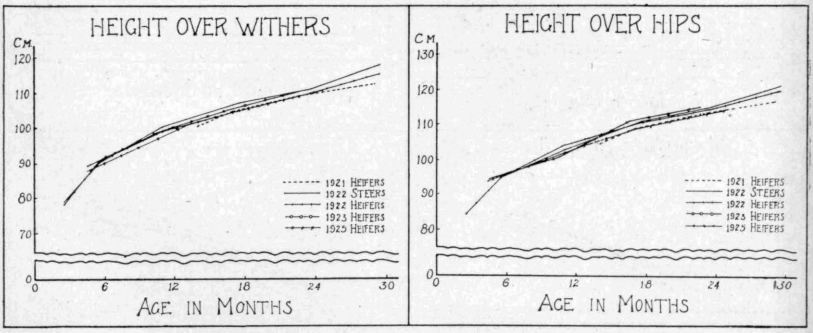

Figure 13. The two measurements showing the very least influence of the condition of nutrition. This type of growth curve is not very different from the growth in weight shown by cattle which are fed to grow at a fair rate but without very much fattening. (See in Figure 14 the growth curve for the Missouri steers.) Apparently height over hips and height over withers grow at a rate which is almost the same whether feed is abundant or the cattle are almost starving.

fatness. The only important exceptions are paunch girth and flank girth. The former scarcely reflects fatness at all and the latter does so only to a very slight extent except in animals so fat that the flanks begin to fill out with fat—a higher degree of fatness than is often seen in immature cattle on the range. Both of these measurements are indicators of paunchiness or "fill" more than anything else, and their small size in early March merely reflects the lessened space occupied by the digestive organs as a consequence of the long winter period of scanty feed. Cannon circumference (taken midway between the knee and pastern joints), surprisingly enough, behaves more like the measurements of fatness than like the measurements of bone length.

Three things happen during the period of scanty feed from late fall through the winter, which together account for nearly all the observed changes in the shape and weight of young range cattle during that period.

They are: an actual loss of fat, a decrease in the space occupied by the digestive organs, and continued growth of the skeletal tissues and perhaps also of the muscles.

It may well be asked whether skeletal growth is checked at all by such periods of scanty feed as these cattle experienced. The graphs for height over withers, height over hips, and the measurements of the head, do not show any very certain indication of any abnormal slowing-down of growth during these periods. They are almost smooth curves like those which characterize the growth of cattle fed enough to permit steady growth unaccompanied by much fattening, as for example, may be seen in studies of the growth of dairy cattle.* On the other hand, the data on certain other measurements which are primarily skeletal (for example, the measurements of pelvis, hooks and pinbones, chest depth and body length) do seem to show clearly that even skeletal growth is distinctly slowed down during the winter season of scarce feed.

The most plausible explanation of this apparent discrepancy of the evidence on skeletal growth seems to us to be that the entire skeleton does not behave as a unit in this respect, but that some parts of it are more severely affected by scanty feed than other parts are. The "growth impulse" (if we may be permitted to use such a term to describe something which is as yet explained poorly, if at all, on a mechanistic basis) is stronger in the bones of the head and the long bones of the limbs than it is in the ribs or the pelvic bones. Height over withers and height over hips seem to grow more regularly with age and to be less influenced by conditions of feeding and management than most other measurements are. Many investigators use height over withers as a better measure of growth (where they are thinking of growth as not including fattening) than live weight is. Others use some function of the height-weight relationship to express fatness or to express numerically the less well-defined concept of "body build." Our data do not show any other measurement which seems as well adapted for such use except height over hips, which behaves in practically the same way.

GROWTH AFTER FEED SHORTAGE

It will have been noticed that the gains in weight from mid-April to June, and usually from June to mid-July, are exceedingly rapid, being nearly as large as might be expected of steers being fed a heavy ration of grain in feedlots. This rapid gain compensates to some extent for the slow gains or actual losses experienced in the winter and early spring. Does it fully compensate for those so that the steer at the end of summer is as large as he would have been if he had been fed a fairly liberal ration

*Brody, Samuel, and Ragsdale, A. C. 1925. The Course of Skeletal Growth in the Dairy Cow. Missouri Agricultural Experiment Station Research Bulletin No. 80.

Hansen, Paul. 1925. The Development of the East Prussian Black and White Lowland Cattle from Birth to the End of Growth (translated title). Arbeiten der Deutschen Gesellschaft für Züchtungskunde, Heft. 26.

during the winter? We cannot answer this directly from our own experiments, but we can point out what seems to us likely to be the correct answer based on the experience of experiment stations in other States. Figure 14 shows the curve of the average weight of our cattle (using the same data as in Figure 1) and superimposed on it are two curves copied from data given in Research Bulletin No. 62 of the Missouri Station. The curve for Missouri steers shows the average weights of Hereford-Shorthorn steers fed under farm conditions to make moderately good gains at all seasons, but without really fattening in the commercial sense of the word. The Minnesota steers (described in Bulletin No. 193 of

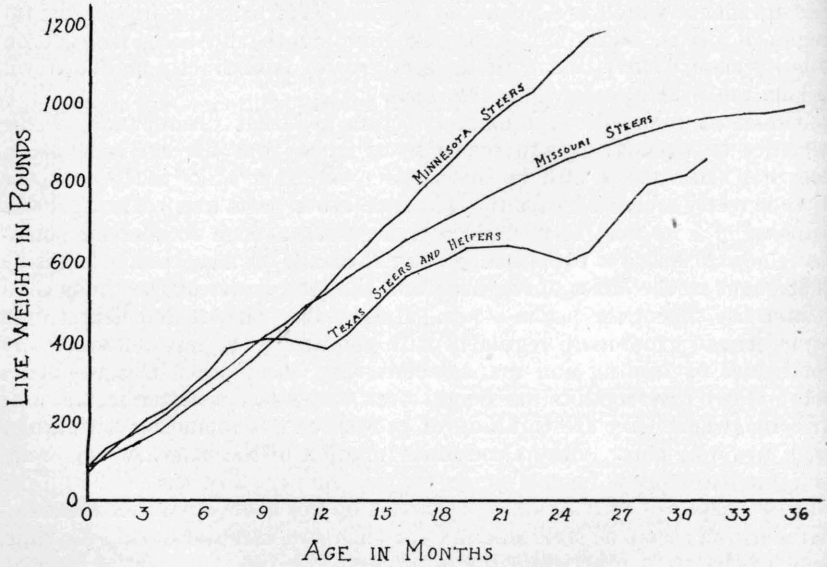

Figure 14. The growth of steers in average weight under different systems of feeding. The Minnesota steers were fed all the grain they would clean up quickly and all the roughage they would eat. The Missouri steers were fed to make good gains without any considerable amount of fattening. The Texas steers were on year-long pasture and received no other feed except their mothers' milk up to weaning time and a very little supplemental feed late in very severe winters.

the Minnesota Station) seem to have been fed so as to make the largest practical gains, but they were not full-fed for the greatest possible gains, as would be the case with steers being fattened for show. It will be noticed that the Texas cattle gain more rapidly during late spring and early summer than the Missouri cattle ever do, but that this period is too short and the period of scanty pasture is too long for the Texas cattle to gain as much total weight during the entire year as the Missouri steers did.

The Minnesota steers gained all the time at a rate not very different from that of the Texas cattle at their best. The absence of anything resembling a growth cycle in the case of the Minnesota steers is quite strik-

ing. The decreasing rate of growth of the Missouri steers with age is quite like the curves of growth of body measurements and like the weight-curves of dairy cattle. The peculiarly cyclic nature of the curve for the Texas cattle may safely be considered to be only a reflection of the abundance or scarcity of nutritious pasturage at various times of the year on the range.

The very rapid growth of the Texas calves up to about weaning time is worth special notice. Most of them are born early in February to early in April at about the time when grass usually is getting well started. Their mothers' milk production not only receives the normal stimulus of parturition, but also receives that stimulus which comes from being given access to fresh green grass after a long period on relatively dry forage. When the calves are old enough to start eating grass, the vegetation is still tender, but increasing rapidly in its content of digestible nutrients. By the time the calves get to making much use of the vegetation it is usually approaching that stage of its development when the total content of digestible nutrients is greatest. This combination of circumstances is the foundation for Texas' position as a great breeding State and source of feeder calves.

It is to be presumed that the Texas steers would eventually reach the same weights as the Missouri steers, but that more time would be required for them to do so. Perhaps we cannot altogether deny the possibility that some cattle have their growth so checked by the winter periods of scanty feed that they can never reach the mature size which would have been theirs if they had always had at least a fair supply of feed. On the basis of other experiments, we think this unlikely. Moreover, it is commercially of small importance, now that most cattle used for beef are slaughtered at weights far short of maturity, anyhow. We think it is, however, a point which deserves special investigation whenever available facilities can be had.

The exceedingly rapid gains made by the cattle late in the spring and early in the summer are quite in harmony with or even exceed the findings of the Salina Station in Utah already mentioned, and this agrees also with the findings of the Kansas Station, and of the West Virginia Station in co-operation with the United States Department of Agriculture. In general, it has been found that the thinner cattle are in the spring (provided they are still strong and healthy) the more rapidly they will gain on pasture during the following spring. The thin cattle do not, however, quite catch up with those which are fatter when the grazing season opens. Sometimes this added fatness at the end of the grazing season will procure a sale price enough higher to justify considerable expense for supplemental feeding in the winter. Whether this will be profitable in any particular case depends first of all upon the market in which the cattle will be sold and whether it will pay a distinct premium for the amount of extra fatness to be expected. Then, of course, the cost of such supplemental feeding must be considered, and

often this will be almost prohibitive except on ranches which can raise most or all of the supplementary feed they use.

No doubt many ranching regions could make a more extensive and profitable use of home-grown supplementary feeds than they do at present. For regions where wheat straw and sorghum roughages can be grown, the animal husbandmen at the Kansas Station recommend that calves be fed enough to gain about 100 pounds each during their first winter, yearlings about 75 pounds each, and two-year-olds about 50 pounds each. Such cattle are fat enough in the spring that the packer will bid on them, and yet they are not too fat to do well on grass or in feedlots. With three possible market outlets, such cattle will usually find a ready sale. A plan of this general sort would, no doubt, be useful in much of the Texas Panhandle. Some Texas ranchmen keep certain pastures free of cattle during the summer and in the winter use those pastures for cattle which are to be sold the following spring. This is a form of supplemental feeding which also has the forage-benefiting effects of a system of deferred grazing if rotation of pastures is also practiced. Of course, it involves the risk of losing the reserved grass by fire.

There are, however, many ranching regions where the rainfall or the soil makes the growing of any considerable amount of supplemental crops practically out of the question. If also, by reason of winter rainfall or the nature of the vegetation, deferred grazing is very wasteful of the forage possibilities, then any form of supplemental feeding will be quite expensive. On such ranches it may be distinctly more profitable to let the cattle lose weight through the winter than to pay the feed bill for the supplemental feed which would keep them from losing it. More exact information about the ultimate consequences of the winter period of feed shortage would be exceedingly useful to ranchmen generally.

GENERAL DISCUSSION

The growth described in this Bulletin has been called "normal" growth of range cattle. It is normal in the sense that it is *usual* on the Ranch Experiment Station and is typical of ranches having that general type of vegetation and system of management. It is not normal in the sense of being inherently necessary because of the innate nature of the animal, although something of this sort is approached in the case of skeletal growth.

The things which chiefly distinguish this type of ranching are:

1. Year-long grazing, with little or no supplemental feeding during the winter.
2. Comparatively dry weather during the late fall, winter, and early spring.
3. Vegetation which (especially in the absence of rainy weather) cures on the ground and retains a high nutritive value after frost and far into the winter.

4. A system of mixed grazing in fenced pastures, many of which are not more than two or three sections in area. Cattle, sheep, and goats all run in the same pastures.

In the coast country and in extreme South Texas the winters are milder and the grass comes on much earlier. The character of the vegetation is also different. That in the coast country is generally thought to become harsh and woody when it reaches maturity and to lose much of its feeding value if it is not eaten before it becomes ripe. Consequently, what we have called "normal" growth in this Bulletin may not be normal for the coast country nor for East Texas, where the winter rainfall is much greater and the vegetation still different. We do believe, however, that our findings apply rather generally over the region west of the Blacklands of Texas. The principal variations will be due to local differences in the amount and kind of grass or other supplemental feed used for winter pasture.

The presence of sheep and goats in these pastures may have affected these data slightly, especially in the times of feed scarcity. The grazing habits of these three kinds of animals are not identical,* and when feed is abundant they supplement each other's activities so that greater net use is made of the forage resources than could be made by any one or two of them alone. But sheep can crop the grass much more closely than cattle can and in times of very scanty pasture the cattle doubtless feel the shortage earlier and more severely than they would if the pasture were stocked with cattle alone. This, of course, will not deter the ranchman from stocking his ranch with all three classes of animals. By such stocking he gets the largest net returns. But such stocking, by making his cattle bear the brunt of the period of feed shortage, may make his cattle look less thrifty and weigh less in the spring than those of ranchmen who stock with cattle altogether. This circumstance, although probably of small importance, should be taken into consideration in interpreting what we mean here by "normal" growth.

The weight curves show clearly the underlying reason for the range man's practice of selling his surplus stock in the fall between late September and early December. Since the cattle will weigh little more in April than in the preceding November, they can be kept advantageously only if, as often happens, the April price is enough higher than the November price to pay interest, death losses, labor costs, and a profit. But they are much less desirable butcher animals in the spring than in the preceding fall on account of having grown in skeleton at the expense of their fat. In the fall they can go to the packer or the feeder or the man who has roughages and wishes to carry them through the winter on those rough feeds until grass comes the next spring. But in the spring the cattle are not fat enough to be very attractive to the packer, most of the feeders have used up their surplus of feed and are, there-

*Cory, V. L. 1927. Activities of Livestock on the Range. Texas Agricultural Experiment Station Bulletin No. 367.

fore, out of the market, and only the man with grass to be used is a strong bidder for cattle which have been carried through the winter with little or no supplemental feed. On account of the perishable nature of grass, such a man is a very strong bidder until his pastures are stocked, but will not take many more than that no matter how cheap the price may be.

This leads to a consideration of the ranchman's relation to grass. He is primarily a user of grass and only incidentally a cattle raiser. That is to say, he has certain grass and other forage resources which come and go with the passing of the seasons. His problem is how to harvest and sell those crops of forage to the best advantage. According to the physical nature of his lands and forage, according to the economic outlook for different kinds of live stock, and according to his personal likes and dislikes, the ranchman selects cattle or sheep or goats or some combination of them as likely to turn his annual crop of grass and forage into the greatest net profit and personal satisfaction to himself. He has no control over the weather and little control over his soil or the kinds of vegetation which grow on it. If he does not use the vegetation within at least a reasonable time after it is produced it is wasted. However, it is not produced at a uniform rate all through the year. If he stocks his range heavily enough to use all the vegetation which grows in May or July, his stock will overgraze the pastures, injure the forage, and partially starve themselves during the winter and early spring. If he stocks lightly enough for his young stock to go through the winter without loss of weight, much of the summer and early fall forage will be wasted. A compromise between these extremes is necessary. And in deciding just where to make that compromise, he must be careful not to injure the vegetation permanently. Such injury from overgrazing is most apt to occur when the grass is shortest, that is, late in the winter and early in the spring. This is another reason for selling surplus stock in the fall or very early winter unless the spring price is very much higher. Once a steer has been carried through the winter and well into the spring, he almost ceases for several months to be a draft upon the carrying capacity of the pasture. If he can be carried into April without permanent damage to the vegetation, he can be carried a few months longer. The steer in April is to the ranchman a machine for marketing grass rather than so many pounds of beef of such-and-such a grade.

Price, of course, dominates the question of when to sell, but the spring price per pound must be very distinctly higher than the fall price if spring selling is to be profitable. Spring prices for stocker and feeder cattle usually are higher than fall prices on account of the great surplus offered for sale in the fall. The ranchman who is unusually well situated to produce cheap supplemental winter feed can often take advantage of this price difference and can profitably make a practice of carrying surplus cattle through the winter season for sale in the spring, when prices are higher. Conserving the carrying capacity of the pastures should always have a prominent place in calculations on this subject. The

physical factors which determine the normal course of growth will probably always dictate a major peak of selling in the fall, when grass passes its period of maximum feeding value. Economic factors may create a minor peak of selling in the spring, when those who have grass, but no cattle, bid high enough to buy from those who have wintered more cattle than they really need to use their own pasture resources.

SUMMARY

This Bulletin describes the growth of cattle on the range in southwest Texas from birth to about thirty months of age.

The cattle were on year-long range and received supplemental feed only when that was thought necessary to carry them through the winter in strong enough condition to use the spring grass well. In the eight winters covered by these data supplemental feeding was essential in two winters and was thought advisable for short periods in three other winters.

The data on which this Bulletin is based consist of the weights taken regularly eight times each year of all calves born on the Ranch Experiment Station from 1921 to 1929, inclusive. They include more than five hundred steers and heifers born in nine different years and divided among three different kinds of breeding. Linear measurements taken four or more times are included for five different groups of high-grade Herefords born from 1921 to 1925.

Weights increase very rapidly from mid-April to mid-July and in some years until early December. Usually the rate of increase slows down from late summer to early winter. From mid-October to mid-January the weights generally increase only a little. From mid-January to early March there is usually an actual loss which is barely regained by mid-April. Variations from the typical rates of growth in some years are very directly connected with variations in the weather and in the condition of the pastures in those years.

Steers are slightly heavier than heifers.

Quarter-blood Brahmans are slightly heavier than half-blood Brahmans or high-grade Herefords.

Breed and sex differences in these weights were relatively unimportant as compared with differences directly traceable to the condition of the pastures.

Measurements which are affected much by the degree of fatness increase slowly from September to March and very rapidly from March to September. Examples are chest width, loin width, width at pin bones, and heart girth.

Measurements of body circumference (flank girth, paunch girth, and heart girth) increase slowly from September to March, but very rapidly from March to September.

Measurements of the head and of the length of long bones increase at about a normal rate regardless of season or of pasture conditions. Ex-

amples are height over withers, height over hips, elbow height, head length, and width at eyes.

Other skeletal measurements are intermediate in this respect. The evidence indicates rather clearly that the skeletal growth is really slowed down in parts of the body by the winter period of scanty feed.

Whether mature size is permanently stunted at all by the winter periods of feed shortage or is only postponed to a later age than would be the case with cattle well fed the year round is not clear. These data and the data from other experiments at other stations lead us to believe that very little if any of such permanent stunting occurs.

Because of the shape of the normal weight curve of cattle, most of the surplus cattle from the range naturally go to market in the fall or very early winter. This also helps protect the range from over-grazing during the winter and early spring. Spring sale of surplus cattle from the range requires a distinctly higher price per pound in the spring than in the fall, or a reasonably cheap home-produced supply of supplemental feed if it is to be as profitable as sale in the fall.

REFERENCES GIVING AN INTRODUCTION TO THE TECHNICAL LITERATURE ON GROWTH

Those who wish to read more about the technical physiology and description of growth will find a good introduction to the subject in the book, "Growth" (Growth, 1928, Robbins, Brody, Hogan, Jackson, and Greene. 189 pp. 83 fig. Yale University Press) written by workers at the Missouri Agricultural Experiment Station and will also find there abundant references to the published studies of other men, so that the subject can be pursued still further if they desire. Among the technical publications which will be helpful to one who wishes to pursue a detailed study of some of the problems of growth should be mentioned the following Research Bulletins from the Missouri Agricultural Experiment Station:

No.	Yr. Published	Title and Authors
28	1918	Effect of Limited Food on Growth of Beef Animals. P. F. Trowbridge, C. R. Moulton and L. D. Haigh.
31	1918	Some Factors Influencing the Rate of Growth and the Size of Dairy Heifers at Maturity. C. H. Eckles and W. W. Swett.
43	1921	Studies in Animal Nutrition. I. Changes in Form and Weight on Different Planes of Nutrition. C. Robert Moulton, P. F. Trowbridge, L. D. Haigh.
45	1921	The Effect on Growth of Breeding Immature Animals. F. B. Mumford.
62	1923	Normal Growth of Domestic Animals. F. B. Mumford and others.
67	1924	The Change of Form with Age in the Dairy Cow. Samuel Brody and A. C. Ragsdale.
96	1926	Growth and Development with Special Reference to Domestic Animals. I. Quantitative Data. F. B. Mumford and others.
104	1927	Growth and Development with Special Reference to Domestic Animals. IX. A Comparison of Growth Curves of Man and other Animals. Samuel Brody.